An overview of chemical exposures in your environment

Lunch & Learn: EPA Finance Center

5/18/17

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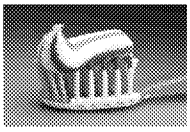
National Center for Environmental Assessment

**Oak Ridge Institute for Science and Education Participant*

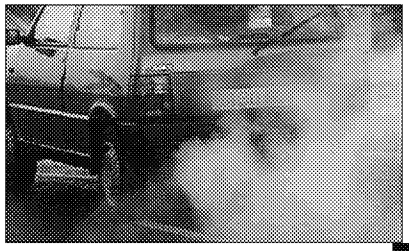
Conflict of Interest Statement

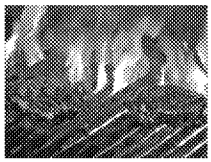
- We have no conflicts of interest to disclose.
- The views expressed in this presentation are those of the author and do not necessarily reflect the views or policies of the U.S. EPA.

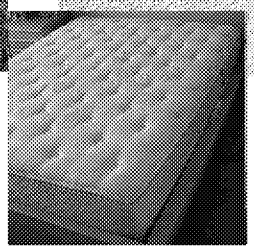
Everything is a Chemical



- Pesticides/Herbicides
- Nanomaterials
- Perfluorinated Chemicals
- Plastics/Polymers
- Polycyclic Aromatic Hydrocarbons
- Flame Retardants







Chemical Regulation

- **Toxic Substances Control Act (TSCA)**
  - "chemicals of commerce"
  - Recently revised in 2015-2016; Lautenburg Act for Chemical Safety
- **Federal Insecticide Fungicide Rodenticide Act (FIFRA)**
  - Herbicides, insecticides, and pesticides
- **Food Drug Administration (FDA)**
  - Drugs, medical devices

Introduction to Toxicology

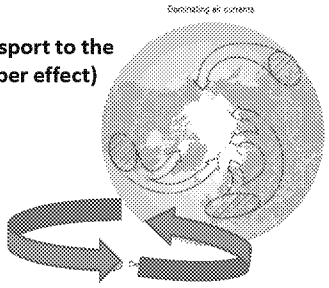
- Integrative discipline concerned with study of adverse effects of chemicals on living organisms
  - Ecotoxicology, environmental toxicology, human health
- Factors influencing toxicity
  - dosage, acute/chronic exposures, route of exposure, species, age, sex, environment
  - History: "The Dose makes the poison" -*Paracelsus*
- Testing methods
  - Non-human animals
  - Alternative testing methods (high throughput, modeling, etc)

The Chemical Problem

- Too many chemicals, not enough time/resources
  - Estimated 80,000 chemicals registered
  - Current estimates ~30,000 substances in commercial use
- Expense associated with testing
  - EPA guideline study for developmental neurotoxicity can take 1-2 years, cost $1 million
  - Large numbers of chemicals, difficult to test with traditional methods
- Human Health Risk Assessment: function of hazard identification, dose-response relationship, exposure characterization, and risk characterization

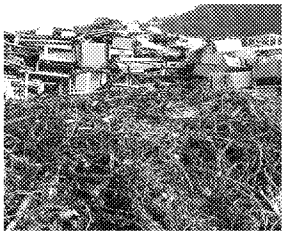
Chemical Exposures & Transport

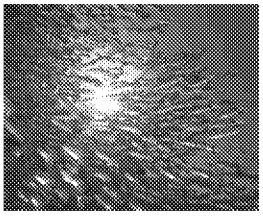
Long Range Transport to the Arctic (grasshopper effect)



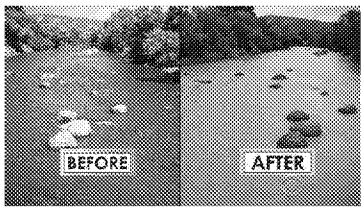
Landfills

E-waste



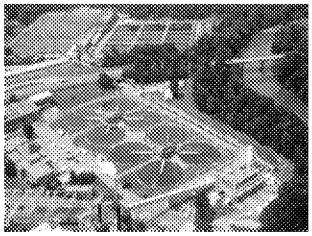


Surface Waters/Oceans

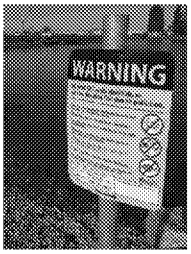


Spills (pictured, Gold King Mine CO)

Land Application of Biosolids



Wastewater Treatment



Diet/food webs

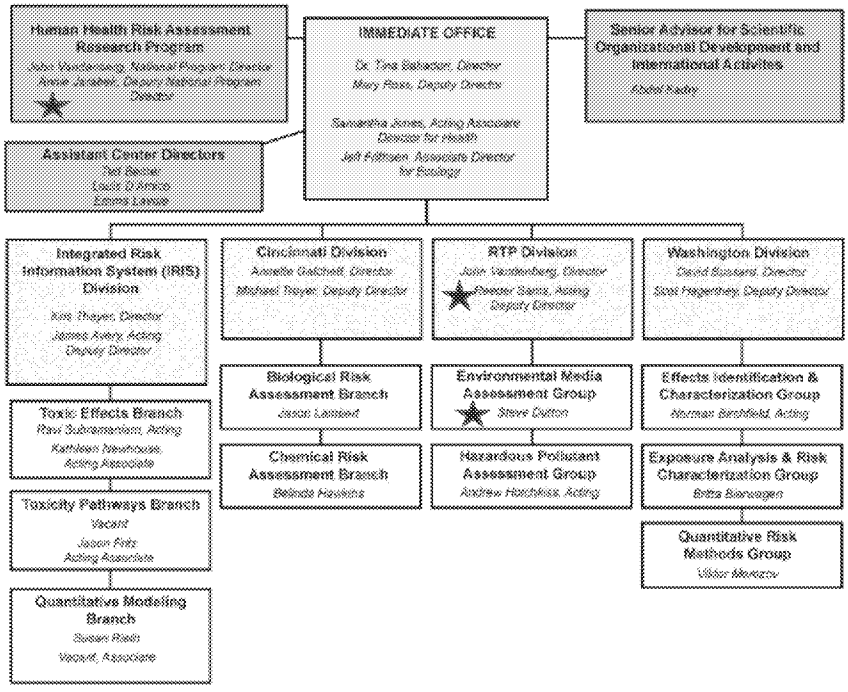
National Center for Environmental Assessment

- Part of the Office of Research & Development
  - Split across multiple divisions: RTP, Cincinnati, Washington
- Diverse Staff
  - Biologists, chemists, ecologists, engineers, epidemiologists, toxicologists, & statisticians
- Guidance Documents / Work Products
  - Guidance documents
  - Criteria documents
  - Risk assessments
  - Risk assessment methodologies
  - Models

National Center for Environmental Assessment

- human health and ecological risk assessment- a robust scientific process used to determine how pollutants or other stressors may impact human health and the environment
  - interacts with other agencies, the scientific community, industry, policy-makers, and the public
  - innovative risk assessment methods and tools that help extrapolate between experimental data and real-world scenarios, improve our understanding of uncertainties, and facilitate careful evaluation of scientific evidence

National Center for Environmental Assessment



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Last updated on January 9, 2017

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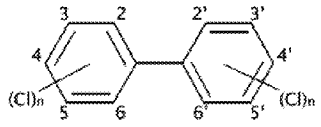
Toxicology & Risk Assessment

- Systematic review of existing human and animal data on potential health impacts
- When sufficient data exist, development of toxicological reviews that develop recommended levels of exposure that do not come with increase risk of adverse health effects

- Look at a few case example chemicals:
  - Polychlorinated Biphenyls (PCBs)
  - Phthalates

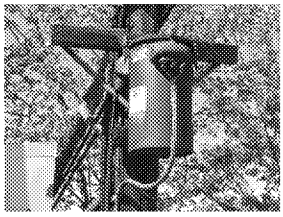
Polychlorinated Biphenyls (PCBs)

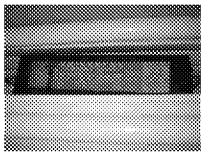


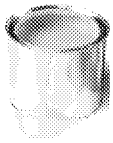
- 209 congeners
- Sold as commercial mixtures (1930-1977)
  - Aroclor (US); Kanechlor (Japan); Clophen (Germany), many other trade names
  - >600 million kg/yr produced in US alone
- Persistent Organic Pollutants
  - banned by TSCA 1979
  - Stockholm Convention's Dirty Dozen 2001
- Not currently in use
  - PCB contamination continues through disposal of PCB-containing products and environmental partitioning
  - Many congeners have long half lives; bioaccumulative/biomagnification

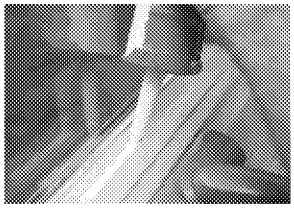
Extensive environmental contamination (ex: Great Lakes; Anniston, AL, NYC's Hudson River, etc.)

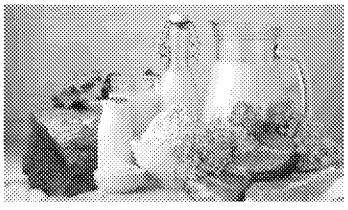
Sources of PCB Exposure



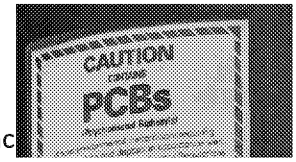






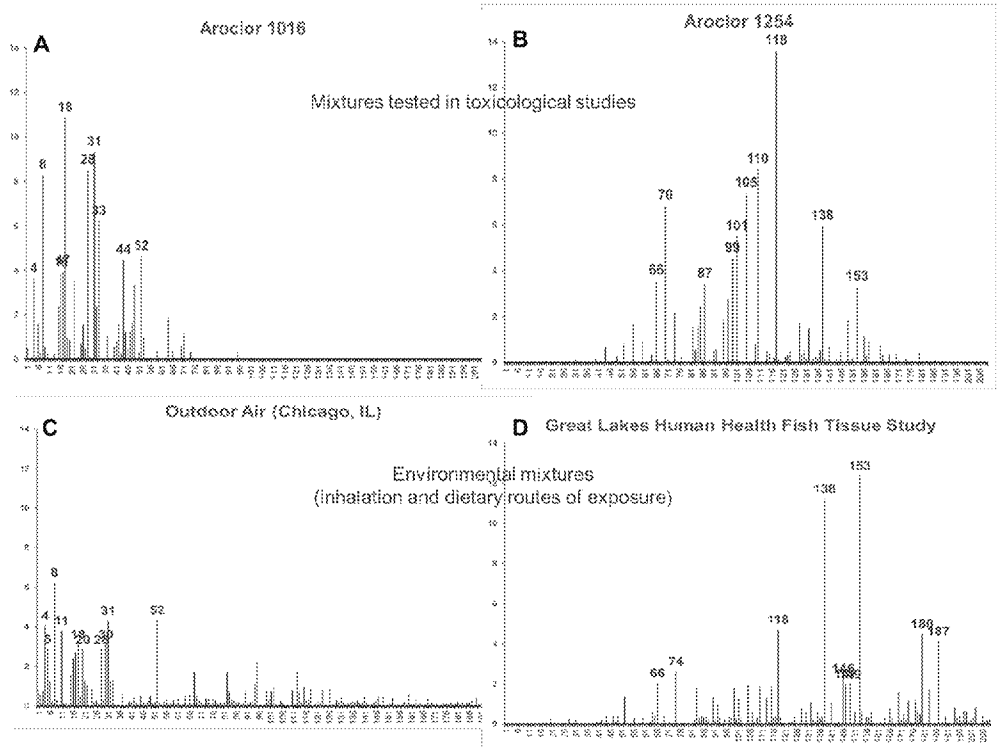


Human Exposure to PCBs



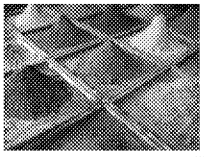
- General population
  - Contaminated food (fish, meat, dairy, others)
  - Inhalation of contaminated air (indoor settings; schools)
  - ~2ng PCB/kg-d (FDA; 2003)
  - Greater Exposures– recreational fishers; native American/subsistenc
- Occupational exposures
  - Inhalation and dermal contact in workplaces where PCBs are present
- Childhood Exposures
  - Lactational transfer through breastfeeding
  - Inhalation exposures in schools
- Difficulties with Characterizing PCB Exposures
  - Epidemiological studies use PCB serum levels, breast milk, or adipose tissue (commonly detected congeners: PCB-138, -153, and -180; PCB -28, -118, -180)
  - Exposure data consisting of only a few congeners may not accurately reflect exposures to other PCBs, which may be biologically active

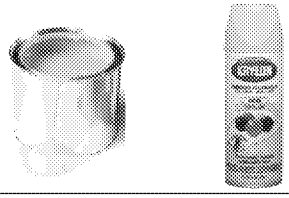
Congener Compositions of Aroclor Mixtures versus Environmental Mixtures

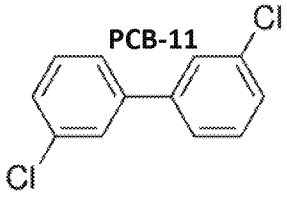


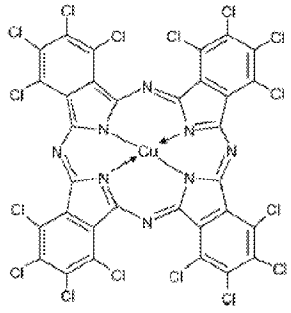
Emerging PCB Sources

- Manufacturing processes result in inadvertent production of PCBs
  - Pigment production (PCB 11, 28, 52, 77, 209)
  - Paper recycling and colored inks
- Emerging issue, high levels of lower chlorinated congeners observed in water samples; PCB-11 specifically
  - Toxicity of PCB-11 and uptake/accumulation not well understood
  - PCB-11 detected in humans
- Widespread Environmental Distribution
  - Atmospheric transport globally PCB-11
  - point sources and industrial/municipal waste water









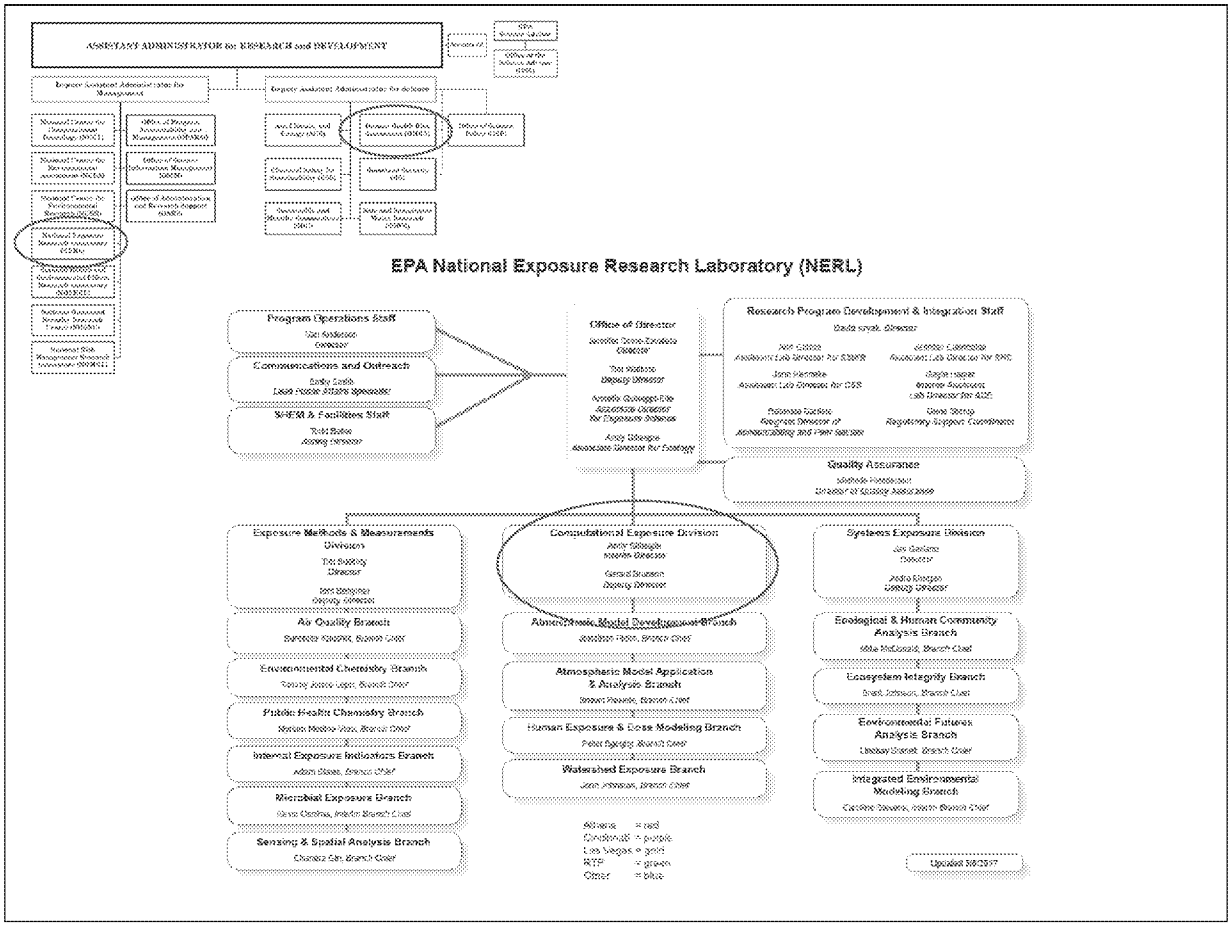
Phthalocyanine green (pigment)

PCB-11 may be a result of direct exposure in humans; currently being evaluated by NTP

PCB Exposure & Health Outcomes

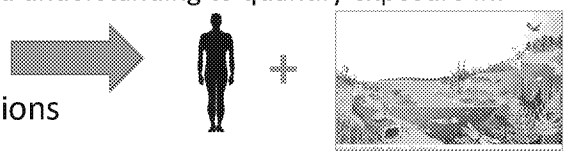
- PCBs have been shown to impact variety of organ systems
- The modes of action are congener-dependent
- Animal Studies evaluating PCB toxicity have observed:
  - Thyroid Effects
  - Neurological effects
  - Immunological effects
  - Reproductive effects
  - Hepatic Effects
  - Developmental Effects
  - Other organ system effects

- Currently, IRIS PCB assessment (non-cancer) will consider health effects listed above associated with exposure to PCB mixtures as they are found in the environment.



National Exposure Research Laboratory

- Exposure science
  - Develops tools and understanding to quantify exposure in:
    - Humans
    - Ecosystems

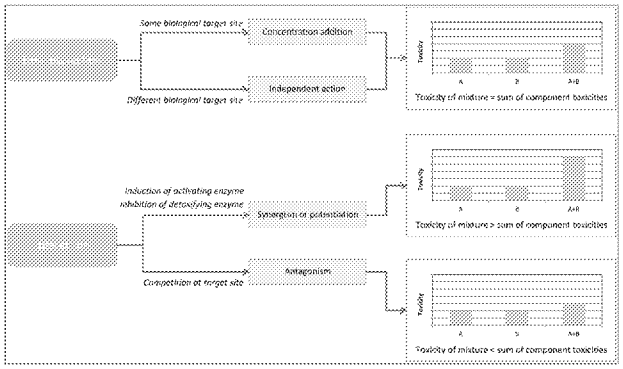


- Answers the questions
  - Determining risk
  - How to reduce or prevent risk
  - Are mitigation strategies successful
- Some of NERL's work is centered around
  - Monitoring methods development
  - Exposure/dose process characterization
  - Decision support tools
  - Predictive modeling
  - Tools for decision making
  - Source apportionment

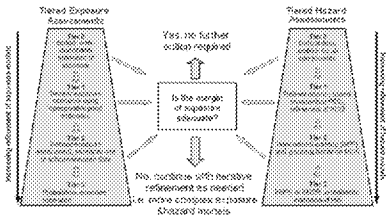
https://www.epa.gov/aboutepa/about-national-exposure-research-laboratory-nerl

Mixtures research and cumulative assessment

- Making all of those (~80,000) chemicals even more complicated…
- Chemical-by-chemical assessment
  - TSCA and REACH do not require consideration of cumulative exposures when determining human health effects
  - Underestimate toxicity
- What happens when we look at chemicals together/jointly?
  - Additive, Synergistic, Antagonistic
- Cumulative assessment
  - WHO



RSC Adv., 2016, 6, 47844. doi: 10.1039/c6ra05406d



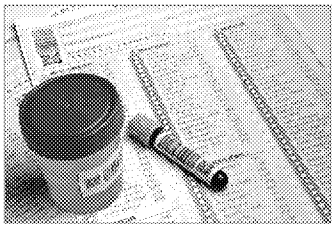
Price et al. Environmental Sciences Europe 2012, 24:26. doi:10.1186/2190-4715-24-26

Rapid Exposure and Dosimetry (RED) project

- RED is one of the current Chemical Safety for Sustainability (CSS) projects
  - Research projects (e.g. CSS) extend across labs/centers
- RED group
  - Human and ecological exposures for ***prioritization***
  - develop the data, tools, and evaluation approaches required to generate ***rapid exposure predictions***
  - models of human and ecological exposures, identification or generation of new high-throughput exposure data (e.g., chemical use or property information, consumer product use data, and consumer product and article chemical compositions, and ecological/biological monitoring data)
  - development of innovative ***statistical techniques*** for evaluating exposure predictions against available monitoring data.
  - develop the scientific approaches from ToxCast to predicted real world doses.
  - Rapid prediction allows ***prioritization*** based upon risk of adverse outcomes due to ***environmental chemical exposure***

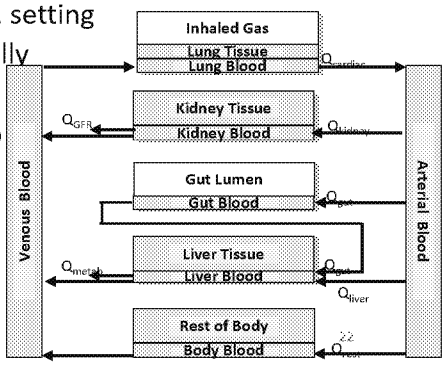
Understanding chemicals and quantifying exposures

- Biomonitoring data (human biological media)
  - Metabolites
  - Blood (serum and plasma), urine
    exhaled breath, breast milk, hair, teeth,
    saliva, etc.



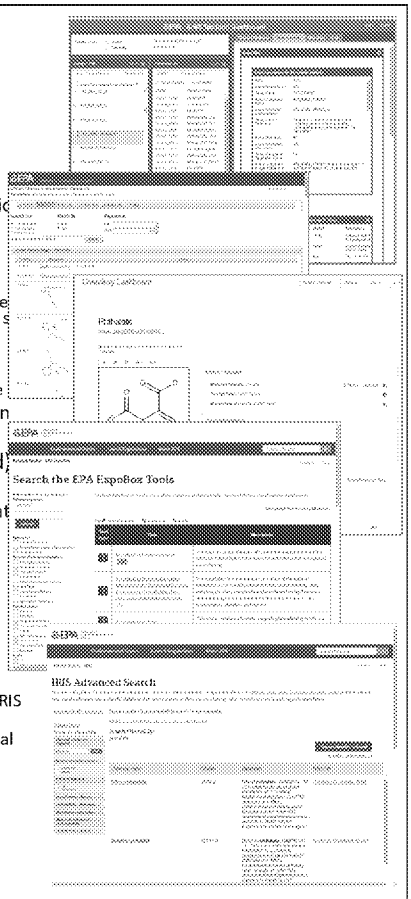
http://www.umweltbundesamt.de/en/topics/health/commissions-working-groups/human- biomonitoring-commission/reference-hbm-values

- Physiologically Based PharmacoKinetic (PBPK)
  - PK origins in medicine
  - Time and concentration to determine dose
  - Extended to different exposures/ranges in an environ. setting
  - "PB" Based on the body compartments (mathematically modeled) instead of something entirely empirical
  - Body is arranged in a series of "compartments" set up towards a specific tissue
- High Throughput ToxicoKinetic (HTTK)
  - Large number of chemicals
  - Tying HTTK to rapid exposures



EPA databases and models

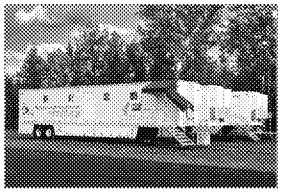
- ToxCast (Toxicity Forecaster)
  - https://actor.epa.gov/dashboard/
  - Over 9,000 chemicals and approximately 1000 assay endpoints
  - explore the data from a chemical or an assay viewpoint, biological activity for the chemic
    assay combinations, downloaded by the user.
- CPDat (Chemical and Product Database)
  - https://actor.epa.gov/cpcat/faces/home.xhtml
  - >43,000 chemicals to a set of terms categorizing their usage or function from publically available
    sources. Unique ***use category*** taxonomies from each source are mapped onto a single common s
    of ***~800 terms***.
- SHEDS-HT (Stochastic Human Exposure and Dose Simulation High Throughput)
  - https://www.epa.gov/chemical-research/forms/registration-download-and-use-sheds-software
  - probabilistic models that estimate exposures people face from chemicals encountered in
    everyday activities
- CompTox (Computational Toxicology) Dashboard (AKA the Chemistry Dashboard
  - https://comptox.epa.gov/dashboard
  - develop innovative methods to change how chemicals are currently evaluated for potent
    health risks
- ExpoBox (Exposure Toolbox)
  - https://www.epa.gov/expobox
  - exposure assessment tools that links to exposure assessment guidance, databases, models, key
    references, and related resources
- IRIS (Integrated Risk Information System)
  - https://www.epa.gov/iris
  - identifying and characterizing the health hazards of chemicals found in the environment. Each IRIS
    assessment can cover a chemical, a group of related chemicals, or a complex mixture
  - an important source of toxicity information used by state and local health agencies, other federal
    agencies, and international health organizations

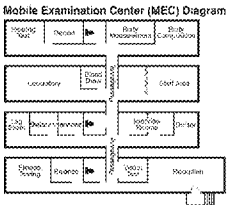


National Health and Nutrition Examination Survey (NHANES)

- A program of studies designed to assess the ***health*** and ***nutritional status*** of adults and children in the United States
- The survey is unique in that it combines ***interviews*** and ***p*** ***examinations***
- Demographics, dietary information, examination data, laboratory data, questionnaire data
- Since 1999, ~5,000 people, once every 2 years,

  100+ chemicals/metabolites

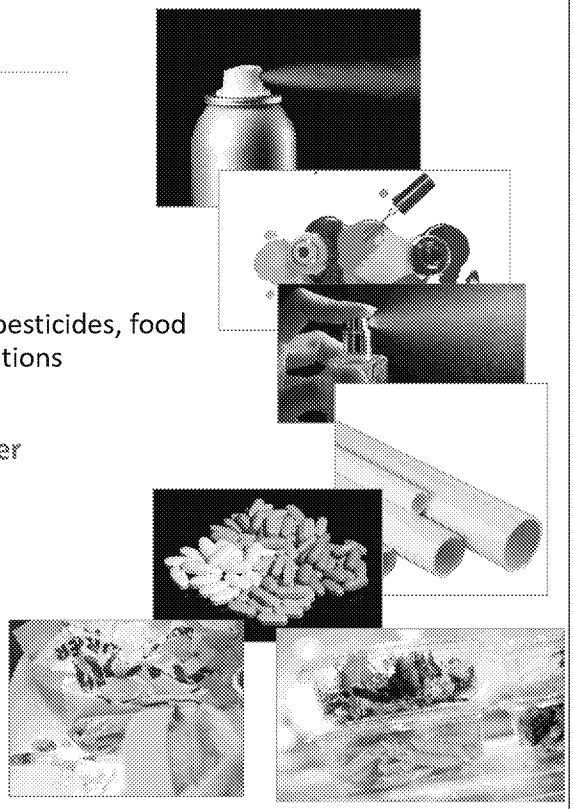




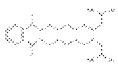
Phthalates

phthal·ate
/ ˈTHaˌlāt/

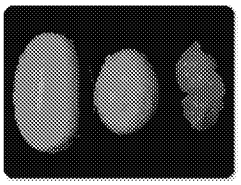
- Phthalates
  - Esters of phthalic acid used as plasticizers
  - Oily liquids are room temperature
- They are in a wide variety of goods
  - Vinyl flooring, tubing and pipes, tablecloths, pesticides, food packaging, cosmetics, skin care, some medications
- Phthalates get into the body by
  - Ingestion – through food, contaminated water
  - Skin – application of products on skin
  - Inhalation (from dust)
- Examples: softener for PVC pipes
- **Phthalates are in everyday products**
  - Metabolizes quickly but frequently exposed
  - Exposure in utero

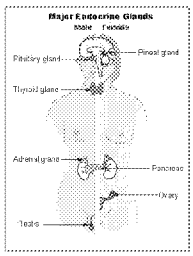


Phthalates

Phthalate	Abbreviation	Uses	Chemical Structures
phthalic acid	---	---	
di-n-butyl phthalate	DBP	Adhesives, caulk, cosmetics, industrial solvent	
diisobutyl phthalate	DIBP	Adhesives, caulk, cosmetics, industrial solvent	
butyl benzyl phthalate	BBP	Vinyl flooring, adhesives, sealants, industrial solvent	
di(2-ethylhexyl) phthalate	DEHP	Soft plastic, including tubing, toys, home products, food containers, food packaging	
diisononyl phthalate	DINP	Vinyl	
diisodecyl phthalate	DIDP	plastic coating, including cook ware, pills, food packaging	

Phthalates

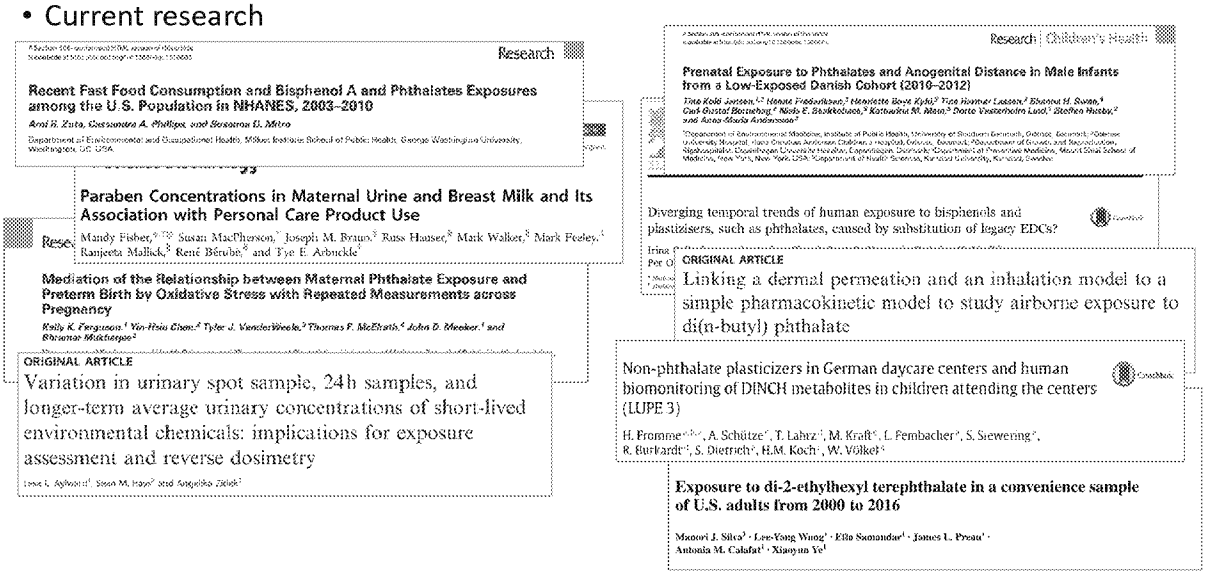




- Some phthalates are endocrine disruptors
  - Rat studies
  - "phthalate syndrome"
    - Infertility, decreased sperm count,
    - changes in reproductive organs
- Phthalate mixture
  - Most of this group (DBP, DIBP, BBP, DINP, DEHP) associated with the "phthalate syndrome"
- How much is manufactured?
  - 90,528 tons DEHP and 2,650 tons DBP in 2012 (Lee et al., Environment International, 2014) and 235,000 tons a year (EPA 2006)
- Which have the highest toxicity of these six phthalates?
  - DBP
- Which can the most frequent exposures?
  - DEHP and DINP
- National Academy of Science 2008 document
  - Cumulative risk assessment
  - investigating mechanism of action to common adverse outcome
- EPA phthalates action plan
  - Several studies have shown associations between phthalate exposures and human health
  - Under TSCA, manufacturers and processors of DPP to notify EPA at least 90 days before starting or resuming new uses of this chemical (DPP in PVC pipe)

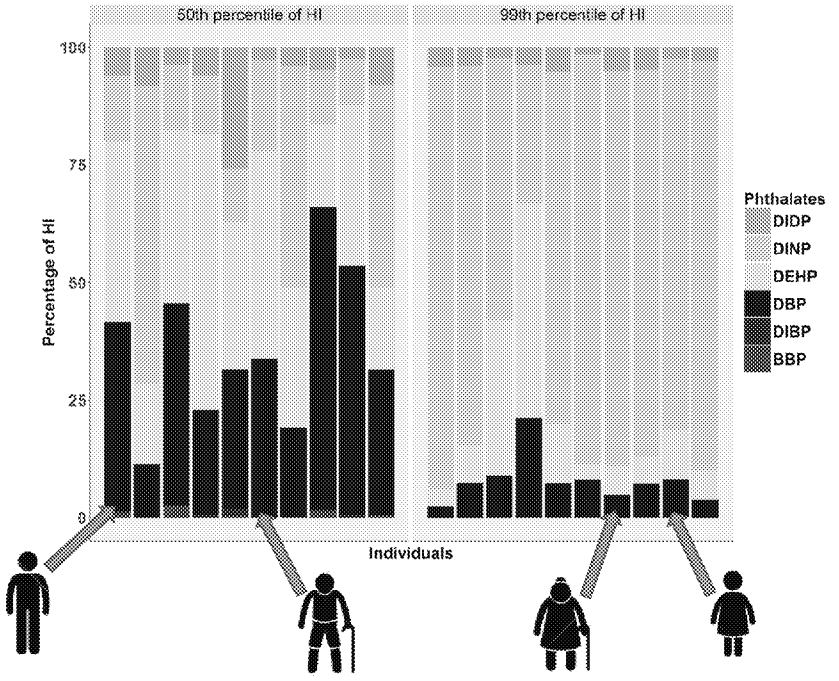
Current Phthalates Research

- Current research



- Differences by age and race
  - Kids (ages 6-10) have higher levels than adolescents (ages 16-17)
  - For years 2005-2008, Mexican-American children had lower levels than White non-Hispanic children and Black non-Hispanic children
  - For years 2005-2008, Black women of child-bearing age had higher concentrations than any other race

Cumulative versus chemical-by-chemical



Being An Informed Consumer

- Read product labels
- Check your products online- some NGO organizations have developed cosmetic/product database recommendations
  - Examples: Environmental Working Group's Skin Deep Database www.ewg.org
  - California Safe Cosmetics Program https://safecosmetics.cdph.ca.gov/
  - Health Canada Consumer Product Safety www.hc-sc.gc.ca

Questions?

- Acknowledgements: NCEA co-workers
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